CHARACTERIZATION OF NEAR-SURFACE WATER USING COMBINED GEOPHYSICAL METHODS

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Combined geophysical methods (Ground Penetrating Radar, seismic and electric), commonly used for imaging purposes, are investigated here for their potential to assess physical properties characterizing the near-surface porous formations and especially those concerning water. Indeed, multioffset GPR data can be employed to estimate the ground water content on a large scale with a satisfactory resolution, the penetration depth depending on soil conductivity. In the same way, combined P-wave and S-wave seismic velocity variations permit the unambiguous identification of the transition between unsaturated and saturated porous layers and the estimation of porosity and bulk and shear frame moduli at greater depths, but with a lower resolution. The high-resolution water content estimations derived from GPR data can be used to solve the problem of trade-off between bulk conductivity (deduced from electrical measurements), water ionic conductivity and water content in Archie's law.
These considerations are illustrated with investigations conducted at two different seasons, each consisting in various concomitant measurements (no seismic in the second investigation), acquired at the same test site located in the alluvial valley of the river Gave de Pau (Southwestern France). The seismic and multioffset GPR data interpretations show consistent geometrical results, i.e., three quasi-horizontal layers, but also provide consistent porosity estimations in the saturated formation. Moreover, the salinity model, obtained by combining electrical and multioffset GPR data interpretations using Archie's law, shows high concentration zones near the surface, which infiltrate deeper in some preferential zones. The second investigation benefited independently measured data of water content, conductivity and ionic analysis on samples of near-surface soils and water table aquifer, which permit to calibrate our quantitative estimations and to check our interpretations.
This study shows the potential of such combined non-intrusive approaches to provide large-scale hydric and ionic transfer models (down to 7 meters depth in our case), and especially to track possible pollutants (most likely linked with intensive agricultural activities in our test site).